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The Spectrum Sharing and Reallocation Dilemma

By Thomas Kidd and Mark Rossow - October-December 2011

The electromagnetic spectrum is a unique resource. While in some ways it is similar to other resources, like oil or water, in other ways, it is very different. The electromagnetic spectrum is typically defined as the set of all non-ionizing radiation electromagnetic frequencies.

The electromagnetic spectrum we are most familiar with is a finite collection of frequencies between about 3,000 cycles per second (kilohertz), or 3 kHz, and 300 billion cycles per second (gigahertz), or 300 GHz. These frequencies are used in radio frequency systems.

The electromagnetic spectrum is unlike any other resource we use. Not only is electromagnetic spectrum finite, it is also instantaneously renewable. The moment one system stops using a set of frequencies — another system can begin using it. As a finite resource, the electromagnetic spectrum is in short supply, but its instantaneously renewable properties provide a near perfect resource for sharing.

The electromagnetic spectrum is managed by allocating particular sets of frequencies, known as bands, to different uses. Some bands may be used for satellite communications while others may be used for radio astronomy. Without allocating different uses to different parts of the spectrum, one system may interfere with the operation of another.

Due to increased spectrum use, it has become difficult to obtain and use many frequency bands in the United States, as well as in many foreign countries. As such, increased electromagnetic spectrum sharing requirements are imposed on spectrum users worldwide. Sharing spectrum can be accomplished in several ways. Technological capabilities, policies and cooperation agreements among users are some of the broad sharing techniques implemented today to maximize the use of the electromagnetic spectrum.

While sharing spectrum has some challenges, it is often possible for some spectrum-dependent systems and equipment to share without causing interference with other systems using the same spectrum. The most common example of sharing is geographical separation, which has been used for nearly a century.

Use of early television frequencies could be shared because television stations were located hundreds of miles apart. Technology can also provide spectrum sharing opportunities. Equipment that transmits radio frequencies at very low power levels may create only a slight rise in background noise. This characteristic provides the ability to reuse radio frequencies efficiently over much shorter distances.

There are also more sophisticated sharing scenarios, including the use of information technology databases that provide detailed information about spectrum-dependent systems and equipment, and their geographical location and transmission media data, as well as what types of signals may cause interference.

Advanced technologies can also "sense" the presence of a radio frequency signal and wait to transmit until other equipment or systems cease use. In many cases, sharing radio frequencies can be accomplished with minimal encroachment for most spectrum users.

However, whether as a result of policy, physics or technology, not all systems can easily share spectrum. Some systems may require interference-free spectrum to ensure operation is not negatively impacted or degraded. Systems that are integral to public safety, such as air traffic control radars, often require very high levels of protection.

Radar generally transmits very strong spectrum signals and receives its own reflected signals, which are incredibly weak. These signals often travel hundreds of miles over their reflected path, and only a miniscule amount of the original transmitted signal is returned to the radar. The high transmission powers of radar are prone to affect spectrum use that is within the transmission areas of radar, and radar is very susceptible to radio frequency interference when it is receiving its very weak returned signal. As a result, radar is generally allocated spectrum solely for radiolocation purposes, and other uses of spectrum are not allowed within the same allocations.

VIRGINIA BEACH, Va. (July 20, 2011) Information Systems Technician 2nd Class Michael Smith, assigned to Riverine Squadron (RIVRON) 3, and Operations Specialist 1st Class Robert McGill, assigned to Navy Expeditionary Combat Command, set up satellite communications equipment during Trident Warrior 2011 at Joint Expeditionary Base Little Creek-Fort Story. Trident Warrior is an annual fleet experiment focusing on new technology. U.S. Navy photo by Mass Communication Specialist 2nd Class Steven Hoskins.

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While the preponderance of spectrum-dependent systems and equipment can share some use of the same radio frequencies, not every system can share with every other system. Some systems cannot successfully operate in the same allocated set of frequencies. Given the escalation of spectrum use throughout the world, the alternative to sharing is reallocation. Portions of the spectrum are reallocated to allow for multiple, new uses of the same spectrum.

Reallocations may be implemented by the relocation of existing spectrum use out of one frequency band and into other frequency bands or by adding additional allocations within the same band. Reallocations of frequency bands that displace existing spectrum use can create a cascading effect that can be extremely challenging, especially if the displaced users cause the users in other bands to be similarly displaced. The ripple of disruption can have unforeseen effects and costly consequences. Reallocation is very similar to rezoning a section of a city and forcibly relocating its residents. Even when done with the greatest skill, it can be a very disruptive process.

Electromagnetic spectrum is a finite resource in short supply. As the United States and many other countries are engaged in maximizing the efficient and effective use of spectrum, spectrum sharing and reallocation considerations and initiatives are addressed daily.

And, due to the importance of spectrum in commerce, national defense and public safety, spectrum sharing and reallocation will continue for many years to come.

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